SEA-BIRD SCIENTIFIC

Transmissometers150921

Transmissometers

User manual

09/2015, Edition 1

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Section 1 Specifications

1.1 Mechanical

1.1.1 Beam Attenuation Meter (BAM) mechanical

Length	19.56 cm
Height	12.45 cm
Width	6.35 cm
Weight in air, water	3.28 kg, 2.06 kg
Depth rating	600 m BAM SSC; 1000 m BAM Std.
Temperature range, operation	-2–38 °C
Temperature range, storage	-40–70 °C
Temperature stability	0.02% FS/°C; 3.28 kg, 2.06 kg
Internal air volume	454 cc

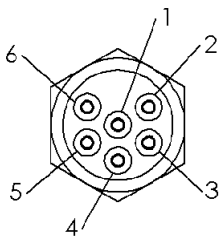
1.1.2 C-Star mechanical

Dimensions	25 cm pathlength: 9.3 x 6.4 x 47 cm; 10 cm pathlength: 9.3 x 6.4 x 29.2 cm
Depth rating	600 m; 6000 m
Temperature range	0–30 °C
Weight in air	25 cm pathlength: 2.2 kg; 3.6 kg (aluminum); 10 cm pathlength: 1.8 kg

1.1.3 C-Rover mechanical

Diameter	10.1 cm
Length	78.3 cm
Depth rating	2000 m
Temperature range, operation	-2–40 °C
Temperature range, storage	-20–50 °C
Weight in air, water	4.11 kg, 0.028 kg
Displacement	4546 ml

1.1.4 MCBH6MP (standard) connector

Contact	Function	MCBH-6-MP
1	Ground	
2	RS232 RX	
3	Reserved	
4	Voltage in	
5	RS232 TX	
6	Reserved	

1.2 Electrical

Input	7–15 VDC
Current draw	35 mA
Linearity	99%
Long-term stability	0.02% FS/hour, 6 hours
Short-term noise	0.027% FS Std dev over 1 minute

1.3 Communication

Sample rate	1 Hz (default) to 8 Hz
RS232 output rate	19200 baud (default) range 2400–115200
Data resolution	14 bit
Digital output maximum	~16380 counts
Analog output maximum (C-Star only)	5 V

1.4 Optical

Wavelengths	470 nm, 532 nm, 650 nm
Optical pathlength	10 cm; 25 cm (C-Star, C-Rover)
Acceptance angle	~1°
Bandwidth (FWHM)	~20 nm
Precision	0.003 m^{-1} @ 1 Hz

Section 2 Operation and maintenance

2.1 Verify sensor operation

Make sure that the sensor operates before further setup and deployment.

⚠CAUTION

Do not supply more than 15 VDC to the sensor. More than 15 VDC will damage the sensor.

1. Connect the connector on the optional test cable (refer to the section on the Test cable on page 13 for details) to the sensor.
2. Remove the cap(s) that protect the optics of the sensor.
3. Connect the battery connectors on the test cable to a regulated power supply set at 12 VDC.
4. Connect the RS232 connector on the test cable to the serial port of the PC. Use a serial-to-USB adapter if the PC has no serial port.
5. Start a terminal communication program such as HyperTerminal® or Tera Term. Select:
   a. Bits per second: 19200
   b. Data bits: 8
   c. Parity: none
   d. Stop bits: 1
   e. Flow control: none.
6. Turn on the power supply.
7. The sensor comes on.
   The data output will show in the terminal program.

2.1.1 Verify analog data output

1. Connect the optional test cable to the sensor. Refer to the section on the test cable for details about test cables.
2. Use a regulated power supply to supply 12 VDC to the sensor or connect a 9V battery to the connectors on the test cable.
   The sensor comes on.
3. Use the probes on a digital multimeter (DMM) to touch the RCA connector on the auxiliary leg(s) of the test cable.
4. Put the red (signal) probe in the RCA connector and the black (ground) on the outside.
   The DMM shows approximately 5 VDC.
5. Put a solid object near the light source of the sensor.
   The DMM shows approximately 0 VDC.

2.2 Verify pre-deployment operation

Make sure that the sensor collects data and operates correctly before deployment.

1. Make sure that the sensor is connected to a PC and power supply.
2. Turn on the power supply if necessary.
3. Put a finger or other solid object in front of the light source.
4. Look at the data output from the signal and the corrected signal.
   They are at or near 0.
5. Look at a clear light path to make sure that the corrected signal is within 100 counts of the clean air value on the sensor's calibration page or the previous user-tracked value.

6. Hold a piece of tape halfway between the windows in the light path to check the mid-range data output values.
   The corrected signal shows a mid-range output value, approximately 7000–11000 counts.

Column	Value	Example output
1	Model-Serial Number	**xxxxxx-0000** 11829 13838 13695 0.003 527
2	Reference	xxxxxx-0000 **11829** 13838 13695 0.003 527
3	Signal	xxxxxx-0000 11829 **13838** 13695 0.003 527
4	Corrected signal	xxxxxx-0000 11829 13838 **13695** 0.003 527
5	Calculated beam c, m^{-1}	xxxxxx-0000 11829 13838 13695 **0.003** 527
6	Thermistor	xxxxxx-0000 11829 13838 13695 0.003 **527**

7. Before deployment, put a drop of diluted detergent on the sensor optics to help keep the optics clean when the sensor is on the water's surface. Refer to Clean the optics on page 7 for details.

2.3 C-Star and C-Rover hardware setup

Attach sensor to frame

- Make sure to electrically isolate the sensor from any metal.
- The manufacturer recommends non-nylon cable ties or monofilament line to attach the sensor to a lowering frame or metal cage.
- If the sensor is attached to a frame with hose clamps, Use a sheet of rubber or dielectric tape to prevent metal-to-metal contact. Use corrosion-resistant 316 stainless steel or titanium clamps.
- Make sure to attach hose clamps around the upper and lower housings on the sensor. Tighten one clamp approximately a quarter-turn, and tighten the other. Move between the two clamps to tighten each equally.
- Do not attach the hose clamps too tightly or the optical path of the sensor may twist, and the data collected may be incorrect.

Sensors that are depth-rated to 2,000 or 6,000 m have a zinc anode installed near the bulkhead connector to protect the sensor from normal corrosion.

Operate the C-Star with or without a pump. The manufacturer recommends the SBE-5T pump, which has an adjustable motor, so flow rates can accurately be controlled to 20–30 ml/sec to flush the flow tube. Attach the optional flow tube if the sensor is operated with a pump.

2.4 C-Star collect data

Use the terminal program commands below for sensors that have digital output. Connect the sensor to a PC or data logger that can receive an RS232 signal at 19200 baud. Connection to a PC or data logger also lets the user save the data collected by the sensor.

Connect sensors that have analog output (C-Star) to a data logger, radiometer, or CTD sensor that can change the analog output of the sensor to digital output. A data logger will merge the CTD and sensor data and align the sensor output with depth or time output.

2.4.1 Common terminal program operations

Command	Parameters	Description
!!!!!	none	Stops the data collected by the sensor. Lets the user to enter setup values. If the sensor is in a low-power mode, turn the power supply off for one minute, then turn the power on and push the "!" key 5 or more times.
$ave	1–65535	The number of measurements that make up each row of collected data.
$mnu	—	Prints the menu of setup values to the PC screen.
$pkt	0–65535	Sets the number of rows of data that are collected between the specified time intervals.
$rls	none	Gets the settings from the flash memory.
$run	—	Uses the current setup values to operate.
$sto	—	Saves the desired setup values to the flash memory.

2.5 Maintenance

The sensor's signal value in air output (CSC_{air}) is supplied on the calibration page. The manufacturer recommends that the user use the CSC_{air}) to:

- monitor the sensor's basic operation
- find out when to clean the sensor
- find out when the sensor is clean.

The manufacturer recommends the maintenance supplies below to clean the sensor:

- 0.2 or 0.4 µm filtered distilled and deionized water.
- one 500 ml bottle of dilute soap such as Microclean® or Dawn®.
- one 500 ml bottle for clean water
- lint-free laboratory tissues or lens papers
- lint-free swabs
- a source of compressed clean air. The manufacturer recommends dry nitrogen.
- a notebook to record maintenance dates and CSC_{air} values.

2.5.1 Clean the sensor

Clean the sensor after each deployment.

1. Flush the sensor with clean fresh water.
2. Use soapy water to cut grease or oil on the sensor.
3. Make sure that saltwater does not dry on the sensor. Salt crystals are difficult to clean.
4. Do a final flush of the sensor with filtered, distilled water.
5. Clean the optics.

2.5.2 Clean the optics

Record and save the data output from the sensor at regular intervals to monitor the performance of the sensor and to see if the optical windows need to be cleaned.

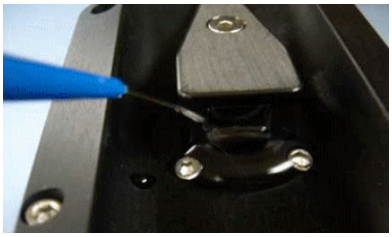
- It is not necessary to clean the windows if the output of the sensor is within 100 counts of the clean air value on the sensor-specific calibration page or the user-tracked value.
- Clean the windows if the output of the sensor is more than 100 counts different from the clean air value on the sensor-specific calibration page or the user-monitored value.

Do the steps below to clean the optical windows. Clean the optics until the output of the sensor data output is—

- within 100 counts of the data output value on the manufacturer-supplied calibration page,
- within 100 counts of the user-monitored data output values, or
- stable, between 100 and 500 counts of the calibration page or user-monitored values.

1. Remove the protective cap(s) to clean the optical windows of the sensor.
2. Mix two drops of soap with 0.2 or 0.4 µm filtered distilled water in a 500 ml bottle.
3. Put some soap solution on the optical window.

Figure 1 Soap solution on window

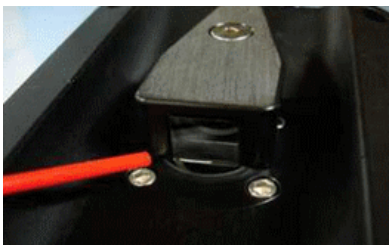


4. Use a lint-free tissue (e.g. Kimwipe or similar) or a swab to rub the optical window to remove particles and oil.

Figure 2 Rub window with lint-free tissue

5. Flush the soap off of the windows with filtered distilled water.
6. Use compressed air to remove any particles that remain and to dry the optical window.

Figure 3 Dry window with compressed air



7. Wet, rub, flush, and dry each optical window two or three times to get a stable clean air value.

2.5.3 Clean and lubricate bulkhead connector

Lubricate the contacts of bulkhead connectors at regular intervals with pure silicone spray only. Allow the contacts to dry before they are connected.

Make sure that the pins have no corrosion, which looks green and dull. Make sure that the rubber seals on the pins are not delaminated. Connectors should connect smoothly and not feel "gritty" or too resistant.

The manufacturer recommends 3M™ Silicone Lubricant spray (UPC 021200-85822). Other silicone sprays may contain hydrocarbon solvents that damage rubber.

DO NOT use silicone grease. **DO NOT** use WD-40®. The wrong lubricant will cause failure of the bulkhead connector and the sensor.

Section 3 Reference

3.1 Calibration

The relation of the signal output to the calibration output is transmittance and will vary from 0 to 1, or 0 to 100%. The relation of transmittance to the beam attenuation coefficient (c) is $Tr = e^{-cx}$.

where:

- Tr = transmittance
- e = natural logarithmic base, ~ 2.71828
- c = beam attenuation coefficient
- x = sensor pathlength

The manufacturer calibrates each sensor and records these values on the sensor-specific calibration page. The calibrated transmittance of the sensor is calculated below.

Tr = $(CSC_{sig} - CSC_{dark}) \div (CSC_{cal} - CSC_{dark})$

- CSC_{sig} = the value of the output in air.
- CSC_{dark} = the value of the output with the beam blocked.
- CSC_{cal}= the value of the output in the clean water used for calibration.

The beam attenuation coefficient is calculated below.

$c = - 1/x \times \ln(\mathbf{Tr})$

$= - 1/x \times \ln [(CSC_{sig} - CSC_{dark}) \div (CSC_{cal} - CSC_{dark})$

3.2 Terminal program operation

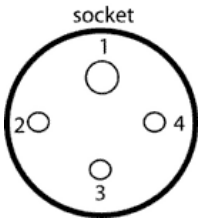
Use Windows HyperTerminal® or other terminal program to operate sensors as an alternative to the host software.

Interface settings				
baud rate: 19200	stop bits: 1	data bits: 8	flow control: none	parity: none

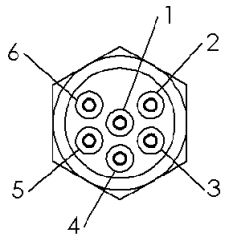
3.3 VSG-4 bulkhead connector

Previous sensor models use the bulkhead connector shown below.

Analog		**Connector diagram**	**Digital**	
Contact	Function		Contact	Function
1	ground		1	ground
2	analog out		2	analog out
3	V+		3	V+
4	analog return		4	RS232 TX



3.4 Bulkhead connector (analog)

Contact	Function	MCBH-6-MP
1	Ground	
2	Reserved	
3	Reserved	
4	Voltage in	
5	Reserved	
6	Analog out	

3.5 Data types

Data type	Description
AI	ASCII integer number
AF	ASCII floating point number
AS	ASCII string, text

Field	Length (bytes)	Data type	Description
Sensor	4	AS	Characters at the start of a row of data
Delimiter	1	AS	Hyphen delimiter
SN	4	AI	Serial number
Delimiter	1	AS	Tab delimiter
Ref raw	5	AI	Reference raw count value
Delimiter	1	AS	Tab delimiter
Sig raw	5	AI	Signal raw count value
Delimiter	1	AS	Tab delimiter
Corr Sig Raw	5	AI	Correct signal raw count value, CSC_{sig}
Delimiter	1	AS	Tab delimiter
c	6	AF	Calculated beam attenuation coefficient in $m,^{-1}$
Delimiter	1	AS	Tab delimiter
Therm	3	AI	Internal thermistor raw count value
Terminator	1	AS	Line feed pair ($0A_{hex}$), end of row.

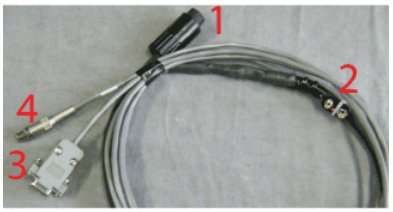
3.6 Protective diode

The C-Rover has a protective diode to prevent damage to the power supply of the sensor up to 30 volts in case power is supplied to the incorrect polarity.

Section 4 Optional equipment

4.1 Test cable

Use the optional test cable to set up and test the sensor before deployment.



1 six-contact connector	**3** db-9 serial port connector
2 9-volt battery connector	**4** RCA connector

1. Connect the six-contact connector into the sensor.
2. Connect the 9-volt connector to a 9-volt battery. As an alternative, it can be connected to a regulated power supply.
3. Connect the db-9 connector to the host PC. Use a USB-to-RS232 adapter cable if necessary.
4. Use the probes on a digital multimeter to see analog output from the sensor. The inside of the RCA is power and the outside is ground.

4.2 Optional equipment: flow tube

The C-Star sensor has an optional flow tube for special uses. Refer to the steps below to remove, clean, and install the flow tube.

1. Loosen the 9/64" stainless steel cap screws in the flow sleeves.
   It is not necessary to remove the screws.
2. Push the flow sleeves toward the middle of the flow tube.
3. Lift the flow tube from the sensor.
4. Remove the O-rings from the flow tube.
5. Wash the flow tube with a mild detergent.
6. Flush the flow tube with clean water.
7. Let the flow tube dry completely.
   Use dry nitrogen to blow dry the flow tube.
8. Make sure the size 122 O-rings on the flow tube and on the optical windows are not damaged.
   Replace them if necessary.
9. Make sure the sensor's optical windows are clean and dry. Refer to the section Clean the optics on page 7 for details.
   Use dry nitrogen under very low pressure on the windows immediately before the flow tube is installed again.
10. Install the flow tube on the sensor.
    a. Line up the stainless steel cap screws on the flow sleeves with the grooves in the flow tubes.
    b. Push the flow sleeves onto each end of the flow tube.
    c. Set the flow tube against the optical windows of the sensor.
    d. Push the flow sleeves out on each end of the flow tube until the outside ring on the sleeve is against the optical window.
    e. Tighten the cap screws in the flow sleeves.

Section 5 General information

Revised editions of this user manual are on the manufacturer's website.

5.1 Warranty

This sensor is warranted against defects in materials and workmanship for one year from the date of purchase. The warranty is void if the manufacturer finds the sensor was abused or neglected beyond the normal wear and tear of deployment.

5.2 Service and support

The manufacturer recommends that sensors be sent back to the factory annually to be cleaned, calibrated, and for standard maintenance.
Refer to the website for FAQs and technical notes, or contact the manufacturer for support at:

support@wetlabs.com

Do the steps below to send a sensor back to the manufacturer.

1. Contact the manufacturer for a Return Merchandise Authorization (RMA).
   Note: *The manufacturer is not responsible for damage to the sensor during return shipment.*
2. Remove all anti-fouling treatment from the sensor before sending it back to the manufacturer.
   Note: *The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes tri-butyl tin, marine anti-fouling paint, ablative coatings, etc.*
3. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.
4. Write the RMA number on the outside of the shipping case and on the packing list.
5. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
6. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

5.3 Waste electrical and electronic equipment

Electrical equipment that is marked with this symbol may not be disposed of in European public disposal systems. In conformity with EU Directive 2002/96/EC, European electrical equipment users must return old or end-of-life equipment to the manufacturer for disposal at no charge to the user. To recycle, please contact the manufacturer for instructions on how to return end-of-life equipment, manufacturer-supplied electrical accessories, and auxiliary items for proper disposal.

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